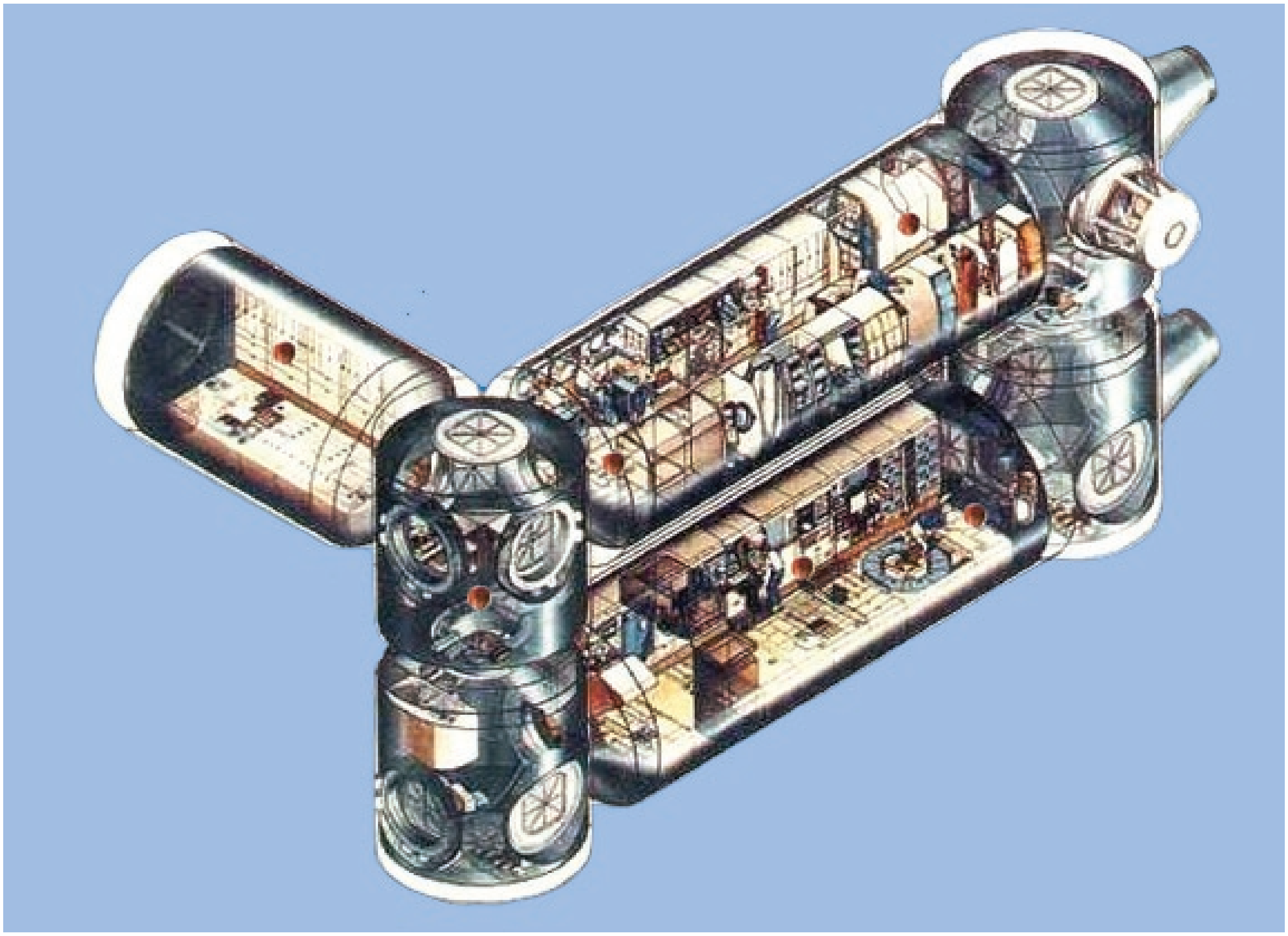


NASA Crew Module
Conceptual Design

A Abstract of Lesson

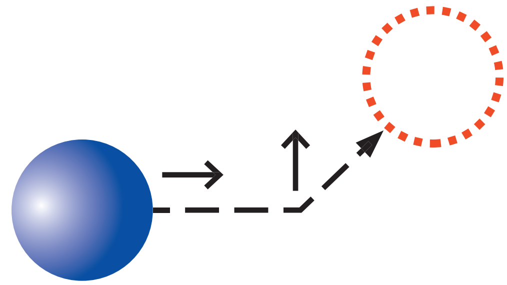
Students use the inquiry process to explore how objects move when unbalanced forces act on them. Students build and operate a CD Glider to simulate motion in a frictionless environment and determine how the Personal Satellite Assistant (PSA) can control its own movements while onboard the test environment of the International Space Station (ISS).

I Introduction

Students use the online PSA activities to learn how forces add and subtract to change the speed and direction of the motion of an object. They discover that an object in motion can be stopped by applying a force to it in the direction opposite to its direction of motion, and they use this knowledge to determine how the PSA will control its motion in microgravity.

Main Concept

An unbalanced force acting on an object changes its speed or direction of motion, or both.



Major Concepts

- An object in motion can be stopped by applying an equal force in a direction opposite to its direction of motion.
- When forces are applied to an object at different angles, the object will tend to move diagonally.

Prerequisite Concepts	Links To Lessons Or Resources That Address Concepts
• Objects move in many different ways, such as straight, zigzag, round and round, back and forth, fast and slow. (2061: 4F (K-2) #1) • The way to change how something is moving is to give it a push or a pull. (2061: 4F (K-2) #2)	Forces and Motion, PSA Lesson 1: Identifying Forces on Earth and in Space http://whyfiles.larc.nasa.gov/text/kids/D_Lab/activities/expressions_motion.html http://whyfiles.larc.nasa.gov/text/educators/activities/2002_2003/inclass/sticky_friction.html http://spaceplace.nasa.gov/ds1_mgr.htm Non-atmospheric Flight 5 - 8 Grade Reading http://quest.nasa.gov/aero/planetary/nonatmosphere/nonatmos5-8read.html ISS: A Home in Microgravity http://quest.nasa.gov/projects/space/iss2001/index.html

Objectives	Education Standards/Benchmarks
1. Students will describe how forces affect the direction of motion and speed of the PSA in microgravity. 2. Students will draw the forces and path they use to hit targets with their CD Gliders. 3. Students will draw and explain the forces and path that will maneuver the PSA around obstacles to a target.	Meets: ISTE 3, 5 Partially Meets: NSES: B (5-8) #2.2, #2.3 2061: 4F (3-5) #1 2061: 4F 6-8 #3

Additional Links and Resources	
Astronauts outside and inside Skylab, America's first space station	http://spaceflight.nasa.gov/gallery/video/skylab/skylab2/mpg/skylab2_mission1.mpg
Showering in Skylab	http://grin.hq.nasa.gov/IMAGES/SMALL/GPN-2000-001710.jpg
Dentist appointment in Skylab	http://images.jsc.nasa.gov/luceneweb/fullimage.jsp?photoId=SL2-02-157
Weightlifting in Skylab	http://grin.hq.nasa.gov/IMAGES/SMALL/GPN-2000-001946.jpg
APOLLO 8: It's Christmas in zero gravity...	http://lisar.larc.nasa.gov/UTILS/info.cgi?id=LV-1998-00027
APOLLO 11: Buzz Aldrin in Lunar Module "Eagle"	http://www.hq.nasa.gov/alsj/a11/BuzzInEagle.mov
APOLLO 11: Landing the Eagle	http://lisar.larc.nasa.gov/UTILS/info.cgi?id=LV-1998-00035
APOLLO 11: "One Small Step..."	http://lisar.larc.nasa.gov/UTILS/info.cgi?id=LV-1999-00001
APOLLO 12: "Pete" Conrad collects samples	http://lisar.larc.nasa.gov/UTILS/info.cgi?id=LV-1998-00038
APOLLO 15 Galileo's Gravity Experiment	http://lisar.larc.nasa.gov/UTILS/info.cgi?id=LV-1998-00046
APOLLO 16: One for the Album	http://lisar.larc.nasa.gov/UTILS/info.cgi?id=LV-1998-00048
APOLLO 17: Skipping on the moon	http://lisar.larc.nasa.gov/UTILS/info.cgi?id=LV-1998-00053

S Schedule

Prior to this lesson, build several CD Gliders (directions provided at the back of this lesson). Depending on time constraints, these gliders can either be used by the students for the experiment, or will serve as examples if students are building the gliders themselves.

Estimated time for lesson: 90 – 120 minutes

M Materials and Equipment

- Chart paper
- 50 cm exercise ball
- Copies of the "Student Handout," one per student or group of students
- Copies of "Directions for Building and Using the CD Gliders," one per group
- 1 straw per student
- 1 CD per group of 3-4 students
- Tape for each group
- Hot glue gun, instant glue, or modeling glue for each group
- 1 water bottle top with valve per group
- Balloons (long or round) for each group
- 1 3x5 index card per group
- 1 small square of transparency film (1 to 2 square inches)
- 1 balloon pump per group (optional)
- Tables that are flat, smooth, and clean
- Bright-colored pieces of paper for targets
- Pictures and videos of the International Space Station (Images can be found at the following Web sites):
    - NASA Human Space Flight Space Station Gallery http://spaceflight.nasa.gov/gallery/images/station/
    - Kennedy Space Center ISS Payload Processing Directorate http://www-ss.ksc.nasa.gov/
    - NASA Human Space Flight International Space Station http://spaceflight.nasa.gov/station/
    - Pictures of the different PSA prototypes (see http://psa.arc.nasa.gov/hist.shtml)
- Computer with Internet connection (see table, next page) to link to http://psa.arc.nasa.gov/

S System Requirements to Run PSA Web Site Activities

Platform	Browser
Windows 95 Windows 98 Windows Me	Internet Explorer 4.0 or later (Internet Explorer 5.0 or later is recommended), Netscape Navigator 4 or later, Netscape 7.0 or later (Netscape 6 is not recommended) JavaScript enabled
Windows NT Windows 2000 Windows XP or later	Internet Explorer 4.0 or later, Netscape Navigator 4 or later, Netscape 7.0 or later, with standard install defaults (Netscape 6 is not recommended) JavaScript enabled
Macintosh: 8.6 thru 9.2	Netscape 4.5 or later (Netscape Communicator 4.7 or Netscape 7.0 are recommended), Netscape 7.0 or later, (Netscape 6 is not recommended) Microsoft Internet Explorer 5.0 or later JavaScript enabled
Macintosh OS X 10.1 or later	Netscape 7.0 or later (Netscape 6 is not recommended), Microsoft Internet Explorer 5.1 or later JavaScript enabled
Browser plug-ins	Flash Player 6 or higher QuickTime Player 6 or higher

P Preparation

- Gather the materials for the lesson (e.g., glue guns, CDs, bottle tops, balloons, index cards, transparency squares, balloon pump, meter sticks).
- Make copies of the Student Handout and directions for building the CD Glider.
- Post pictures of the International Space Station and PSA prototypes.
- Set up the computer with Internet link to http://psa.arc.nasa.gov/.
- Prepare the chart paper with the major concepts of the lesson to post at the end of the lesson.

LESSON Engage

1. Review with students how objects move.

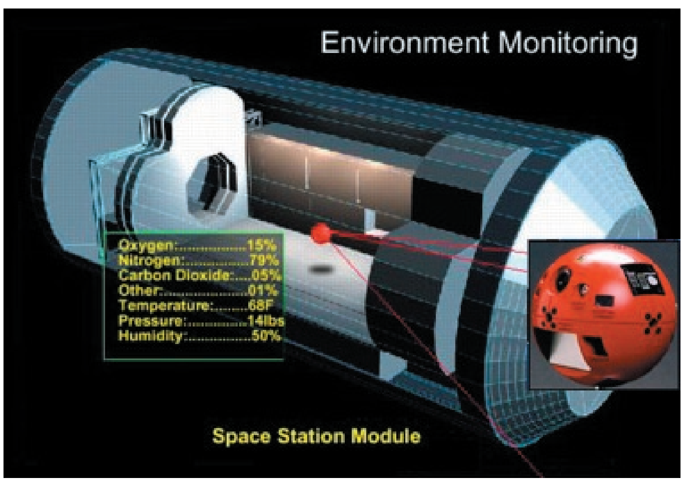
- ☐ Question: How do objects at rest begin to move?
- ■ *Answer: They need a force (a push or a pull) to get moving.*

- ☐ Question: How else can that force affect the motion of a moving object?
- ■ *Answer: A force applied to an object can make an object move faster or slower, or may bring it to a stop.*

- ☐ Question: How do frictional forces affect movement?
- ■ *Answer: Friction causes objects to slow down and stop.*

- ☐ Question: How do moving objects in a frictionless or microgravity environment change speed or direction?
- ■ *Answer: Objects in a frictionless environment move at a constant rate until a new force is applied.*

2. Introduce the scientific question and purpose of the lesson as follows.



PSA Aboard ISS Module
Environmental Modeling Task

If the first or second PSA forces and motion lesson was not completed, give students some background on this robot concept. Tell students that NASA is developing a wide variety of robots to support human exploration of space. One possible concept that NASA has been exploring is a spherical robot that can move around in microgravity or in reduced gravity environments as it provides long-term support for humans. This prototyped robot is called Personal Satellite Assistant, or PSA, and could be used on a wide variety of spacecraft or even on Mars. In developing this robot, NASA would test it in a number of environments, including the International Space Station (ISS).

Tell students that the NASA engineers designing the PSA are especially concerned about its ability to move and stop in microgravity. The PSA must be able to stop at certain points to take readings or to avoid running into things.

Students may recall from Lesson 1 that objects in space are difficult to stop, because there is no friction. This means that NASA engineers need to understand how a force will affect the motion of the PSA, how to stop the PSA, and how multiple forces affect its motion. Tell students that this lesson will explore how to stop and change the direction of motion of an object onboard the test environment of the ISS.

3. Have students apply forces to change the motion of an exercise ball.

Show students a 50-centimeter exercise ball.

- ☐ Question: What will happen to the ball if a force is applied to it?
- ■ *Answer: It will move in the direction of the force.*

- ☐ Question: What will stop the ball?
- ■ *Answer: The ball will slow down because of friction and eventually stop moving, unless it runs into something.*

Select a student volunteer from the class. Tell the student you will count to three, and when you reach three the student should apply a force to the ball. Count to three and discuss with the class what happened to the ball.

- ☐ Question: Is there a way you could stop the ball without letting friction stop it?
- ■ *Answer: (Allow students to share their ideas about this.)*

Select another student from the class. Ask both students to face each other, with the ball between them. Tell the students you will count to three, and when you reach three, each student should apply a force to the ball.

Ask the other students in the class what they think will happen to the ball.

Count to three and discuss with the class what happened to the ball.

- ☐ Question: How would you change the direction of motion of the ball?
- ■ *Answer: (Allow students to share their ideas about this.)*

Now, ask the students to stand 90 degrees apart but still facing the ball. Ask the students in the class what they think will happen to the ball when the student volunteers apply forces 90 degrees apart. Tell the students you will count to three, and when you reach three, each student should apply a forward force to the ball. Count to three and discuss with the class what happened to the ball.

Tell students that today they are going to investigate how unbalanced forces affect the motion of the PSA in microgravity.

Explore - Part 1

1. Discuss the PSA and how it might move around in microgravity.

Have students consider a microgravity environment like the interior of the ISS — a place where there is very little friction.

- ☐ Question: Why does the PSA need to move around the spacecraft or space station?
- ■ *Answer: It needs to move around the spacecraft or station to monitor the environment, take readings in different places, monitor experiments, and be near the astronauts for video conferencing or procedure support.*

- ☐ Question: How do you think the PSA can move itself through a spacecraft without pushing off of walls, objects, or astronauts? How might it stop?
- ■ *Answer: (Have students discuss their ideas about this in pairs or groups).*

2. Have students go to the computers and do the Moving the PSA in a Line experiments.

Tell students that they will be using online activities to learn about how the PSA moves inside the test environment of the ISS, how it changes direction, and how it stops in microgravity.

Have students work individually or in pairs. Have them click "Activities" to go to http://psa.arc.nasa.gov/acti.shtml and complete the following Forces and Motion activities:

- *Introductory video* (if this is their first introduction to the PSA)
- *One Dimension:* This activity will introduce them to moving the PSA in a line in microgravity.
- *Key Ideas:* Encourage students to review the descriptions and video clips in this section once they have done the One Dimension activity to better understand the motion of the PSA. In particular, they may want to review the first two sections.
- *Experiment 3: How many thrusts will you need to apply to stop the PSA in one dimension?*
- *Experiment 4: In what direction must you apply thrust to stop the PSA?*
- *Your Mission: video file* (introduces the purpose of the mission activities)
- *Your Mission: Part 1* (either Easy or Hard)

NAA Transhab Module
Artist Conception

Students can also conduct *Experiment 6: What is the minimum number of thrusts to stop the PSA in one dimension?* for an additional challenge, if they would like.

- Also have students click "PSA Systems" to go to http://psa.arc.nasa.gov/syst.shtml to learn about the part of PSA that allows it to propel itself around in microgravity.
- Students should record their conclusions in their Student Handout.

Explain - Part 1

1. Discuss students' conclusions after doing the activities in which they move the PSA in a line.

☐ Question: How can the PSA move itself through the ISS without pushing off of walls, objects, or astronauts?
■ *Answer: It uses fans or blowers inside itself to push air in the opposite direction in which it needs to move.*

☐ Question: Could the PSA work outside of the ISS, in outer space?
■ *Answer: No. The PSA is fanning the air inside the ISS. Outside there is no air to push with.*

☐ Question: What would the PSA need to move outside the ISS, in outer space?
■ *Answer: It would need to carry its own gas supply or mini rockets.*

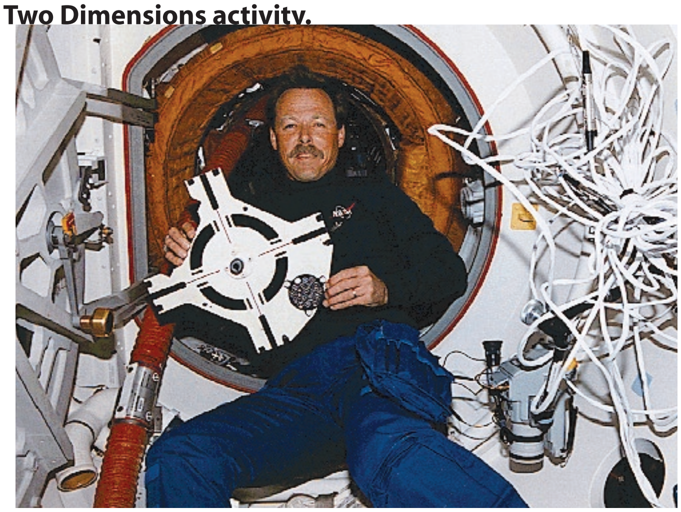
☐ Question: How many clicks does it take to stop the PSA once it is moving?
■ *Answer: It takes an equal number of clicks in the opposite direction to stop the PSA.*

☐ Question: What happens if you click four times to the right, but then only click three times to the left?
■ *Answer: The PSA will slow down a lot, but it won't stop.*

☐ Question: So what can you say about the force that is needed to stop the PSA from moving?
■ *Answer: The force needs to be in the opposite direction and needs to be the same strength as the force used to start it moving.*

Explore - Part 2

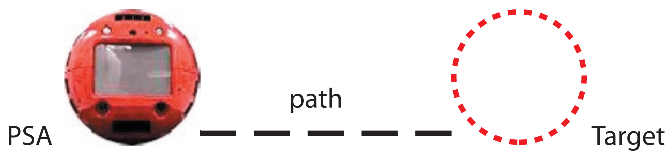
1. Have students do the first part of the Moving the PSA in Two Dimensions activity.



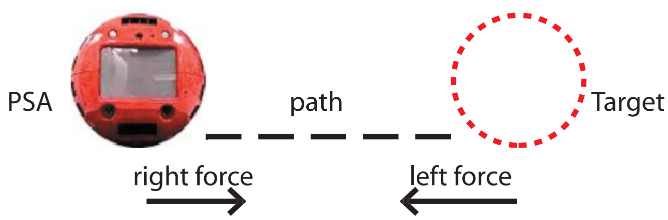
Docking Target Aboard ISS
Astronaut Robert L. Gibson

Use a one-dimensional problem to illustrate how to draw forces to control PSA's motion. On the board, draw PSA and a target to the right in a straight line:

Ask students what the ideal path is for PSA to take to get to the target. Draw this path.



Ask students what forces would be applied to get PSA to take this path and stop in the target. Draw these forces.



Discuss how to change the PSA's direction of motion. Draw a target and PSA on the board. Place the target so that it is at a diagonal up and to the right of the PSA.

☐ Question: Suppose the PSA is moving from left to right in a straight line, but you want the PSA to move to this target, what will the PSA need to do?

■ *Answer:* *The PSA will need to change direction by moving up.*

☐ Question: How will you get the PSA to the target by using blowers that are on the left, right, up, and down? How will you stop the PSA in the target?
■ *Answer:* *Have students discuss their ideas about this in pairs or groups.)*

Have students draw a plan in their Student Handout of the forces they will apply to the PSA in the direction they plan to apply them and the path they think the PSA will take to get to the target when they apply these forces.

2. Have students do the second part of the Moving the PSA in Two Dimensions activity.

Ask students to complete the following Forces and Motion activities at http://psa.arc.nasa.gov/acti.shtml

- *Two Dimensions*: This activity will introduce them to moving the PSA in two dimensions in microgravity.
- *Experiment 5: How many thrusts will you need to apply to stop the PSA in two dimensions?*
- *Your Mission: Part 2* (either Easy or Hard)
- *Quiz Me!:* If students have done all three lessons, you can assess their comprehension of all concepts by having them take, submit and print this quiz listed under "Test Your Knowledge." The quiz is corrected when students click "Submit."

Students can also conduct *Experiment 7: What is the minimum number of clicks to stop the PSA in two dimensions?* for an additional challenge, if they would like.

Students should record their conclusions in their Student Handout.

Explain - Part 2

1. Discuss student conclusions from doing the activities in which they move the PSA in two dimensions.

☐ Question: How did you change the PSA's direction of motion so that it could reach the targets?
■ *Answer:* *We had to apply forces in two directions combining an up or down force with a left or right force.*

☐ Question: What happened to the PSA's path when two forces were applied that were not the same?
■ *Answer:* *Its path moved at an angle from its original direction.*

☐ Question: How did you stop the PSA from moving when it was traveling in two dimensions?
■ *Answer:* *It takes an equal number of clicks in the direction of motion in each dimension. For example if you move it by clicking right four times and up twice, you will have to click left four times and down twice to stop it.*

☐ Question: What is another way the PSA's direction of motion changes, without using the blowers?
■ *Answer:* *When the PSA runs into a wall, an object, or an astronaut, its direction of motion changes.*

☐ Question: How many clicks does it take to stop the PSA after it bounces off the wall and in what direction should you click?

■ *Answer: It takes an equal number of clicks as when the PSA began moving but they need to be in the opposite direction of its new motion.*

☐ Question: So what can you say about the force that is needed to stop the PSA from moving?

■ *Answer: The force needs to be in the opposite direction (or directions) and needs to be the same strength as the force(s) used to start it moving.*

Extend

1. Guide students in the CD Glider Golf activity.

Pass out straws and CD Gliders to each group of two or three students. Place several bright-colored pieces of paper around the classroom. These will serve as targets for students to direct their CD Gliders. For each target, identify a starting point that will require students to work together to guide the gliders correctly.

Swinging Golf Club on the Moon
Apollo Astronaut

CD Glider Golf Rules

- Students must use the straws and work together to blow the CD Glider to the target.
- The glider must be completely on the target for the round to be finished.
- Each time the glider runs out of air, it is considered one stroke.
- The group with the fewest number of strokes to each target wins the game.
- Students may not use anything other than the wind from the straws to move the gliders, but they may pick up the glider to refill it with air.

CAUTION: *Make sure that students who inflate the balloons are not allergic to latex. If they are, use a balloon pump.*

Note: *When tested, students did not like using the straws, but got used to it. Flicking could be used instead for this activity.*

Ask students to record how many strokes they took for each target. Also, have them draw the path that they used to get the glider to each target. Have them draw arrows indicating the direction of each force at the position in the path when it was applied.

2. Have students share their number of strokes for each target and describe how they were able to move the

glider to the target. Ask students to discuss the difficulties they had in controlling the glider's motion.

☐ Question: If nobody were blowing on the glider, what forces would be acting on it?
■ *Answer: The glider would be experiencing gravity and the force of the air pushing up on it.*

☐ Question: What forces were acting on the glider when you were blowing on it?
■ *Answer: The glider was experiencing gravity, the force of air holding it up (lift), the forces of the air being blown on i t (thrust), and friction with the air (drag). (You may want to draw this on the board.)*

☐ Question: In order for the glider to move, what had to be true of these forces?
■ *Answer: The force of air being blown through the straw had to be greater than friction with the air so it could move forward.*

☐ Question: If we want the glider to hover in one place, how would we blow on it?
■ *Answer: Depending on the number of people blowing on it, we would need to balance the forces in every direction. It may not be possible to hold the glider in place with less than three people blowing on it.*

Evaluate

1. **Have students complete the Spacecraft Challenge problem in the Student Handout to evaluate their ability to apply the main concepts in this lesson.**

The PSA needs to move around an astronaut and tools to get to its target. Have students draw the path, the forces they will apply, and at what points they would apply them. Remind them that they will need to remember to draw the forces that will stop the PSA. Have them include a description of the forces they used and explain why they selected these forces to make the PSA change direction and stop.

As a class, create an assessment rubric for this activity. Suggested criteria for the rubric include:

- Reasonable assessment of how unbalanced forces alter the motion of the PSA.
- Reasonable assessment of how to control the motion of the CD Gliders and the PSA.
- Correct identification of forces acting on the CD Glider.
- Clear written presentation of results.
- Clear oral presentation of results.

PSA with Model
Using Computer Aided Design (CAD) Software

Use the rubric to assess students' conclusions from the online activities to make sure they have mastered the major concepts. Also assess students' abilities to apply the main concepts to their CD Gliders and planned PSA path around obstacles.

Consider using chart paper to post the main concepts of the lesson some place in your classroom. As you move through the unit, you and the students can refer to the "conceptual flow" and reflect on the progression of the learning. This may be logistically difficult, but it is a powerful tool for building understanding.

Student Handout

Consider a microgravity environment such as the interior of the ISS — a place where there is very little friction.

Moving the PSA in a Line

Using the online activities at http://psa.arc.nasa.gov/acti.shtml, answer the following questions:

1. How can the PSA move itself through the ISS without pushing off of walls, objects, or astronauts?

2. Could the PSA work on the outside of the ISS, in outer space? Why or why not?

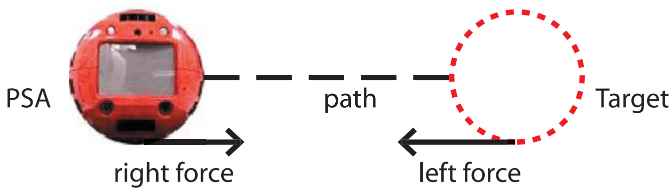
3. How could the PSA move outside the ISS, in outer space?

4. If you move the PSA with three clicks in any direction, how do you stop it from moving?

Moving the PSA in Two Dimensions

Part 1

Example:



1. On the following diagram, draw the path that you plan to use to get the PSA to the target. Draw arrows in the direction you will apply each force at the position in the path when you will apply it.

Part 2

1. What did you have to do to change the PSA's direction of motion?

____

____

____

____

2. If the PSA is traveling to the right and you click the up arrow once, what happens to the motion of the PSA?

____

____

____

____

3. How do you stop the PSA once it is in motion?

4. If you have clicked twice to the right and the PSA hits the wall, how many clicks does it take to stop the PSA from moving and in what direction?

5. What can you conclude about the force that is needed to stop the PSA from moving?

CD Glider Golf

1. In the space below, record the number of strokes your group took for each round of CD Glider Golf. Also, for each target, draw the path that you used to get the glider to the target. Draw arrows in the direction you applied each force at the position in the path when you applied it.

Target number	Number of strokes	Drawing of path and forces applied

2. Describe how your group was able to move the CD Glider to its target. What were the challenges you faced in doing this?

Spacecraft Challenge

1. The PSA needs to move around an astronaut and tools to get to its target. Draw the path that you would use to get the PSA to the target. Draw arrows in the direction that you would apply each force at the place in the path where you would apply it.

2. Describe the forces you used in your solution. Explain how you know that the PSA will change direction and stop with the forces you used.

Teacher Handout (Answer Key)

Moving the PSA in a Line

The PSA uses built-in fans or blowers to push air in the opposite direction that it needs to move. The PSA could not work outside the ISS, because in outer space, there is no air to push with. To move outside the ISS, it would need to carry its own gas supply or mini rockets.

The motion of the PSA in the online activity is initiated by clicking the left or right buttons. To stop the motion of the PSA once it is moving, you must click the same number of times in the opposite direction that the PSA is moving.

Moving the PSA in Two Dimensions

There are several different ways that students could move the PSA to the target. The drawing is meant to get them thinking and is more of a prediction, so is not meant to be assessed.

In order to change the PSA's direction of motion, students need to apply forces in two directions combining an up or down force with a left or right force. Clicking the buttons in perpendicular directions (e.g. right and up) will cause the PSA to move diagonally. To stop the PSA from moving in two dimensions, it takes an equal number of clicks in the opposite direction of motion in each dimension. For example, if you move it by clicking right four times and up twice, you will have to click left four times and down twice to stop it. If the PSA hits a wall, it takes an equal number of clicks as when the PSA began moving to stop it, but they need to be in the opposite direction of its new motion.

The force(s) needed to stop the PSA needs to be in the opposite direction (or directions) and needs to be of the same strength as the force(s) used to start it moving.

CD Glider Golf

CD Glider Golf is a fun activity that is intended to give students a feel for how multiple forces of different magnitudes and directions can affect the speed and direction of an object's motion. The gliders are inherently difficult to control, so it may take some practice for the students to get the hang of how to control the gliders' motion. Their drawn paths should show arrows in opposite directions to start and stop the gliders and in other directions along the path, to turn the gliders.

Spacecraft Challenge

The following is one possible solution for the Spacecraft Challenge. There are others. The important thing to notice is that students have an opposite arrow to cancel out each force, so that the PSA stops. They also need an arrow in a different direction to change each motion. They should explain that they have used equal and opposite forces to stop the PSA's movement and that they have used unbalanced forces to change its direction of movement.

Sample Scoring Tool

4	Explanations for motion of the PSA are correct and clearly presented. Reasoning is logical and clear explanations are provided for the methods used to control the CD Gliders. Oral and written presentations are clear.
3	Most explanations of the motion of the PSA are correct and attempts are made to present clearly. Attempts are made to reason logically and provide clear explanations of the methods used to control the CD Gliders. Attempts are made to provide clear oral and written presentations.
2	Some explanations of the PSA motion are correct and attempts moderately clear. Explanations demonstrate limited logical bases for the methods used to control the CD Gliders. Oral and written presentation skills need improvement.
1	Few explanations of the PSA motion are correct and attempts are unclear. Explanations do not demonstrate adequate knowledge of the lesson content. Oral and written presentations do not effectively express results or reasoning.

Instructions for Building and Using a CD Glider

Have you ever wondered what to do with all those free CDs you get in the mail? Wonder no more—you're going to learn how to simulate being in space!

If you've played air hockey, you know that the puck rides on a thin cushion of air just above the table, allowing it to travel with virtually no friction. We're going to use the same effect to make a CD glide across a table.

Materials

- Hot glue gun, instant glue or modeling glue
- 1 water bottle top with a valve—you can get these at the grocery store (sports bottles). Try to get one with a large valve stem; they control airflow better.
- 1 CD, without any nicks or scratches
- Balloons, either round or long
- 1 balloon pump per group (optional)
- 1 3x5 index card per group
- 1 small square of transparency film (1 to 2 square inches)
- Tape

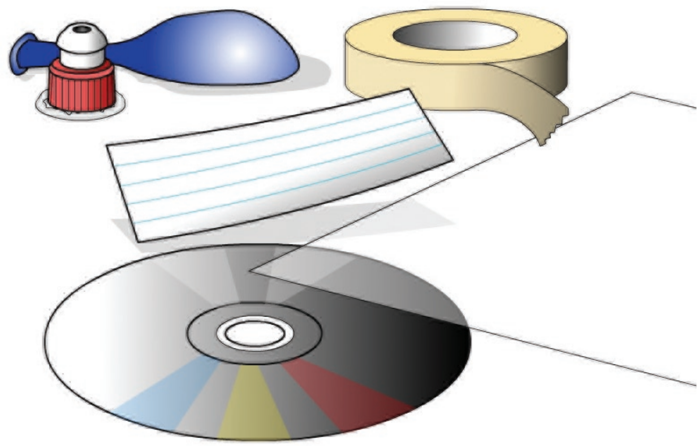
Directions

1. If you are using a glue gun, plug it in and let it warm up.
2. Twist off the top from the water bottle and put the bottle aside—you can drink the water while you work, if you want.
3. Cut transparency film into a circle that fits between the bottle top and the CD. Poke a hole in the middle of the film about the size of a pencil tip. This will allow the air in the balloon to release more slowly.
4. Turn the CD so that the label is facing up and the silvery side with no label is facing down.
5. Draw a line of glue around the edge of the transparency piece. Glue the transparency piece onto the label side of the CD, covering the CD hole. Make sure the transparency hole is in the middle of the CD hole. Don't use so much glue that it is dripping. Make sure the glue does not go though the CD hole to the other side of the CD. This will prevent the CD from gliding properly.
6. Draw a line of glue around the bottom of the bottle top: it should be a thick bead going all the way around. If you are using a glue gun, you will need to do this quickly; neatness does not matter, but don't use so much glue that it is dripping.
7. Before the glue begins to set, place the bottle top on top of the transparency piece over the center hole of the CD and press together. Don't worry about getting the bottle top exactly in the middle; as long as the CD hole is covered by the bottle top, you're OK. The bottle top should be attached to the label side of the CD.
8. After letting the glue set, draw another bead around the joint between the bottle top and the CD. Let all the glue dry.
9. Make a collar out of a 3x5 index card by cutting it in half lengthwise and rolling it so that the diameter roughly matches the bottle top nozzle and it has a height of 1 1/2 inches. This will provide support for the balloon so that it will not fall over as it deflates. Start by threading the balloon through the collar, then inflate, and finally twist the balloon closed and attach to the bottle top.

How to Use:

1. Make sure the valve of the bottle top is closed.
2. Inflate a balloon and twist the bottom, then pull the balloon over the valve. If your valve is shut, you can release the balloon without losing any air.

> ***Note:*** *To attach the inflated balloon, it might be helpful to have one person hold the balloon closed while another puts the balloon over the bottle top to prevent air from escaping.*



3. Carefully pull the valve up until you hear a hiss of air.
4. Place the CD Glider, silvery side down, on a flat, smooth surface
5. Work in pairs for glider "launch" so that one student holds the balloon in the ready position and releases the bottle top and the second student is responsible for blowing the CD with a straw.

Have fun!

Troubleshooting

- *The CD Glider drifts to one side all the time.*
  - Is the table level?
  - Does the joint between the CD and bottle top have any holes or gaps?
- *The CD Glider doesn't glide very far.*
  - Did you open the valve just enough to hear air hiss out?
  - Did you glue the bottle top on the silvery side with no printing?
  - Does the printed side have large scratches or cuts, or excess glue?
- *The balloon flops over and drags on the table.*
  - Try bracing it with tape or a paper cylinder. Be creative!